

# Assimilation of AIRS CO<sub>2</sub> into GEOS5

Andrew Tangborn  
NASA/GSFC and UMBC

Acknowledgements: Steven Pawson, Lesley Ott, JPL AIRS CO2 retrieval team

## Value of Assimilating $CO_2$ retrievals

- Direct comparison between model and observations (O-F) for both passive and assimilated observations.
- Satellite observations can be validated against in-situ observations that are nowhere near the satellite obs locations.
- Tuning of background errors (variance and correlations) by minimizing differences of the analyzed fields with in-situ data. Helps characterize model error.

## Goals of Initial Assimilation Experiments

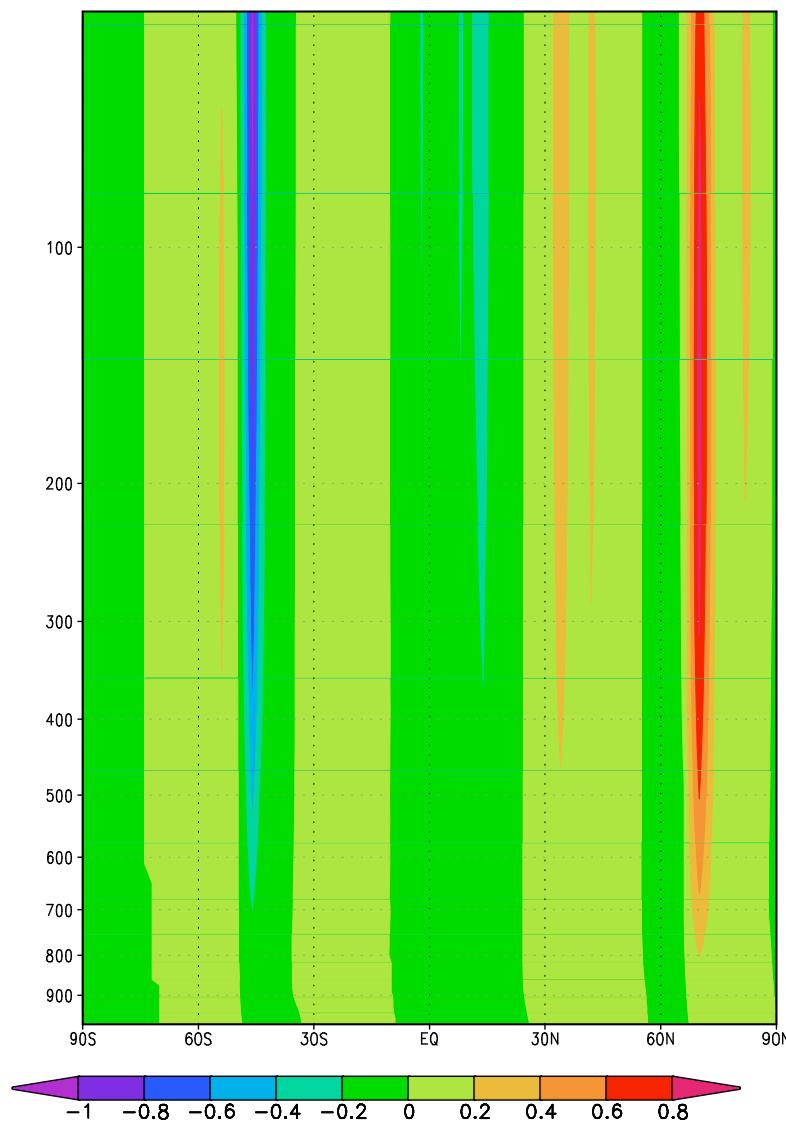
- Determine background errors that result in most optimal solutions when compared to in-situ data (Japan Airlines and CMDL Flask)
- Characterize systematic differences between model and observations.
- Define the impact of assimilating of AIRS retrievals. Does it improve the accuracy of the CO<sub>2</sub> distribution?
- Initial runs for Jan - Nov 2005 (still running).

## Assimilation System

- CO<sub>2</sub> transport driven by GEOS5 (MERRA) met fields, with a 2x2.5 grid.
- Emissions from TRANSCOM (for anthropomorphic sources, 1995) and GFED (for biomass burning, year specific).
- Analysis is carried out in a univariate 3D-Var system.
- CO<sub>2</sub> Background errors are set at a percentage of the CO<sub>2</sub> mixing ratio (ppmv). Provides flow dependent error covariance.
- AIRS retrievals are thinned to the analysis grid.

# Analysis Increments

Background error std = 0.5% of CO<sub>2</sub>



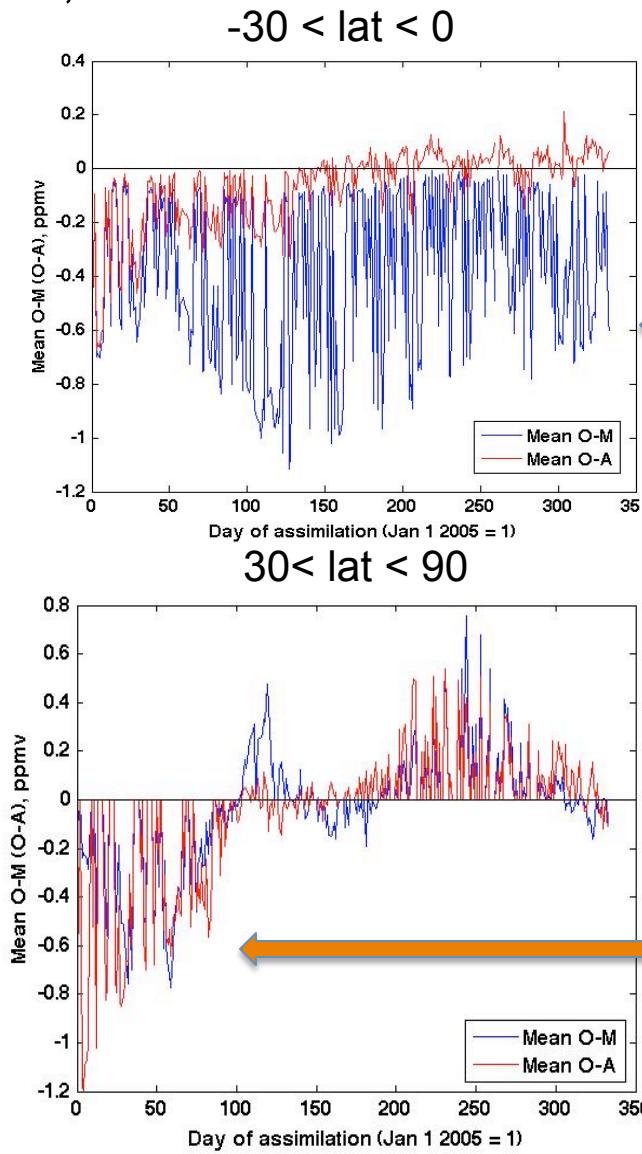
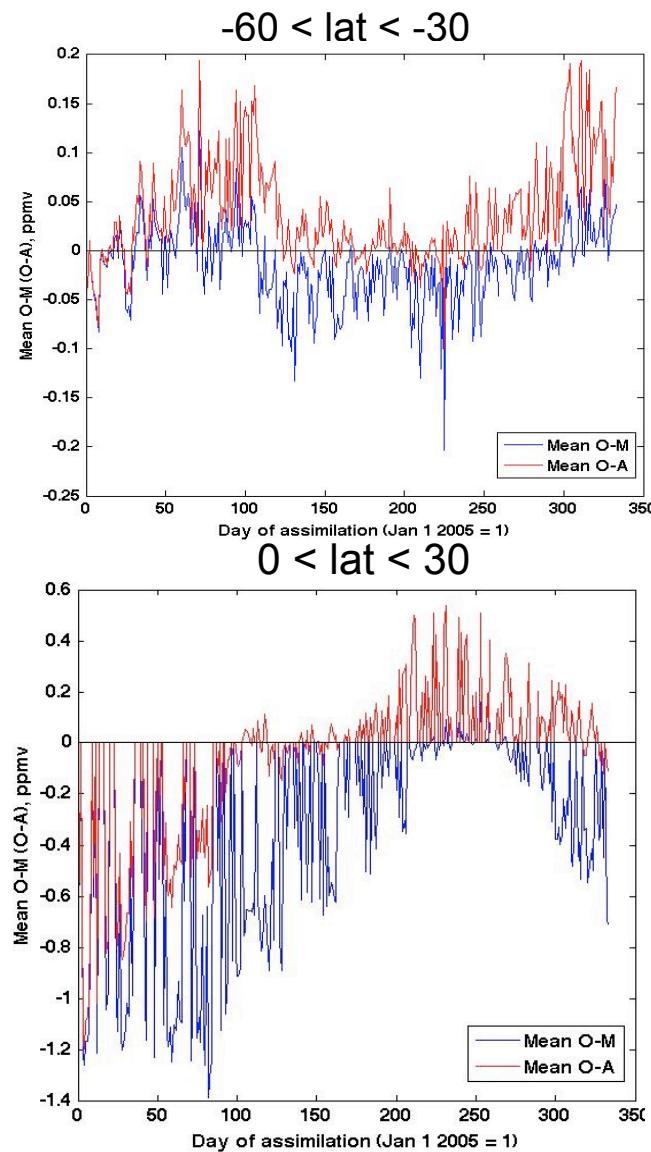
Background error std = 0.1% of CO<sub>2</sub>  
Reduced errors in Stratosphere



# Daily Mean O-F for AIRS observations

Blue – passive : Red – assimilated

Jan 1 – Aug 31, 2005



# AIRS Mean O-Fs

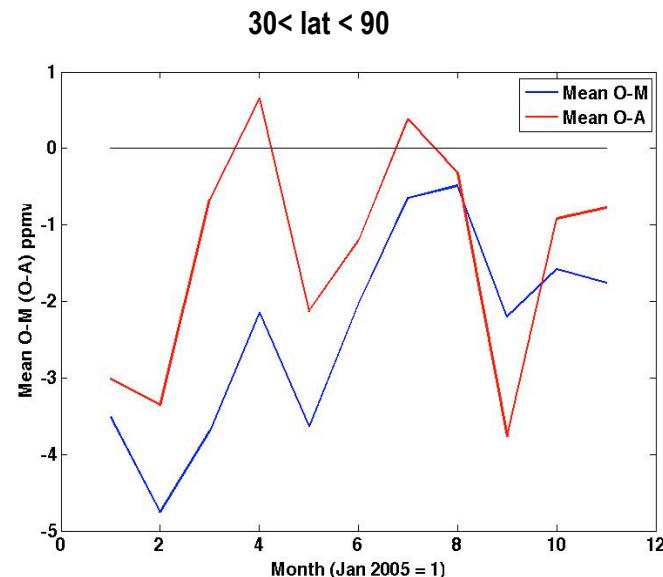
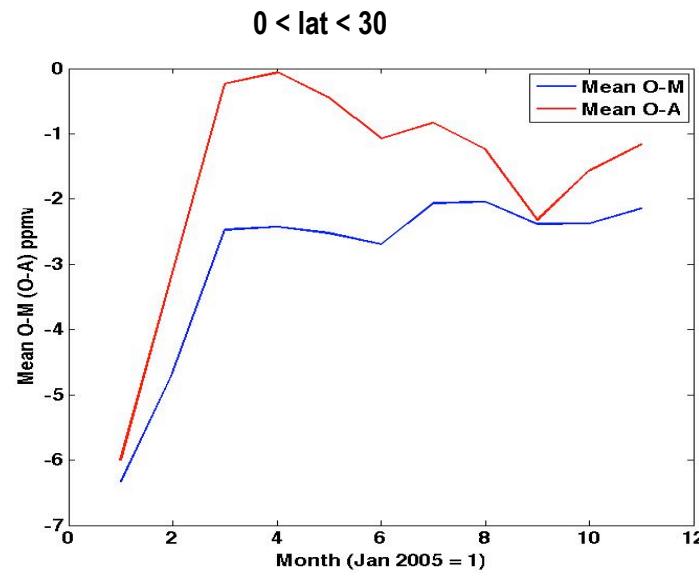
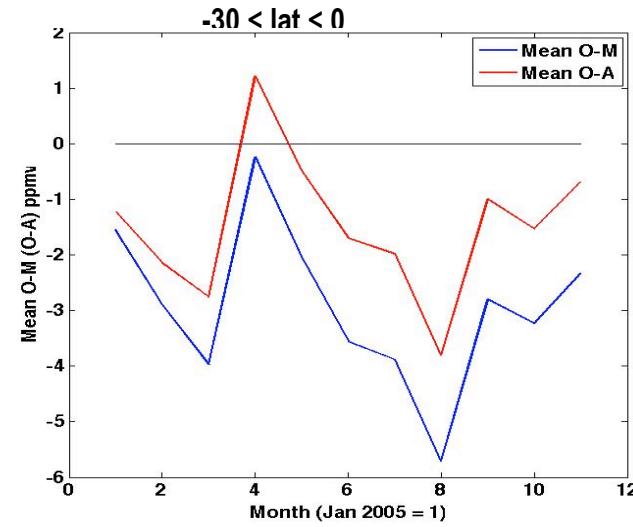
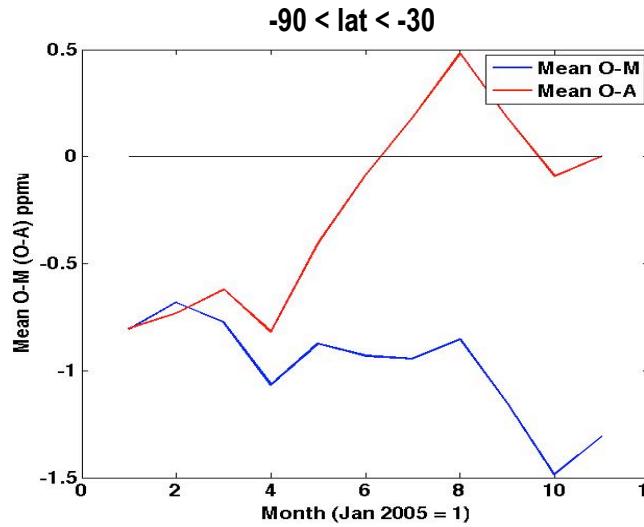
- Negative Model bias in Winter: Does this originate in the model or observations?

Either:

- Model is too high in winter (sources too large?)  
or
  - Retrievals have a negative bias over cold surfaces.
- 
- Comparisons with in-situ data can help with this.

# Monthly Mean Differences with CMDL observations

Jan - Nov 2005



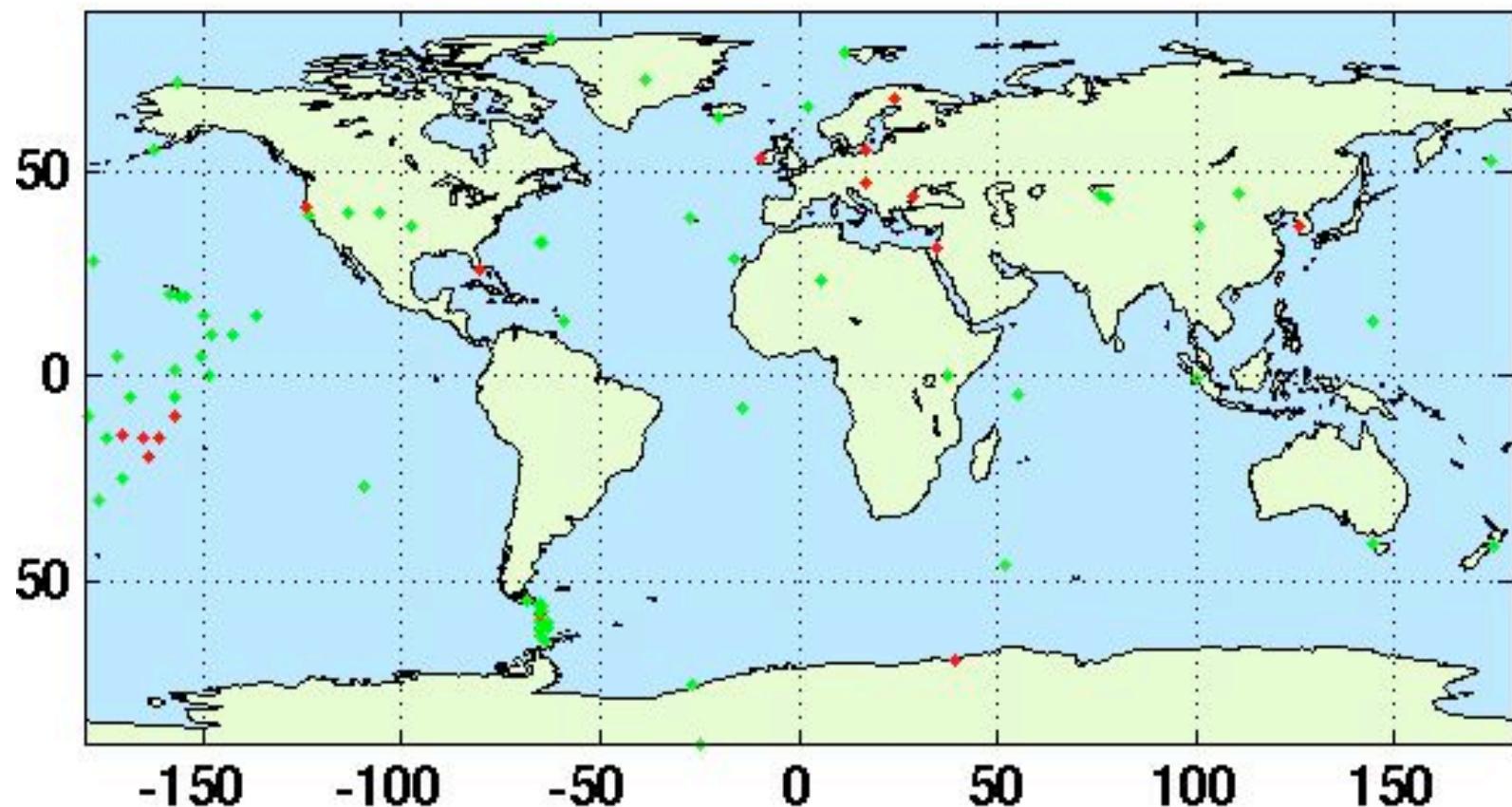
# Comparison with CMDL surface observations

## March – November 2005

Observation Locations:

green = mean assimilation error is lower

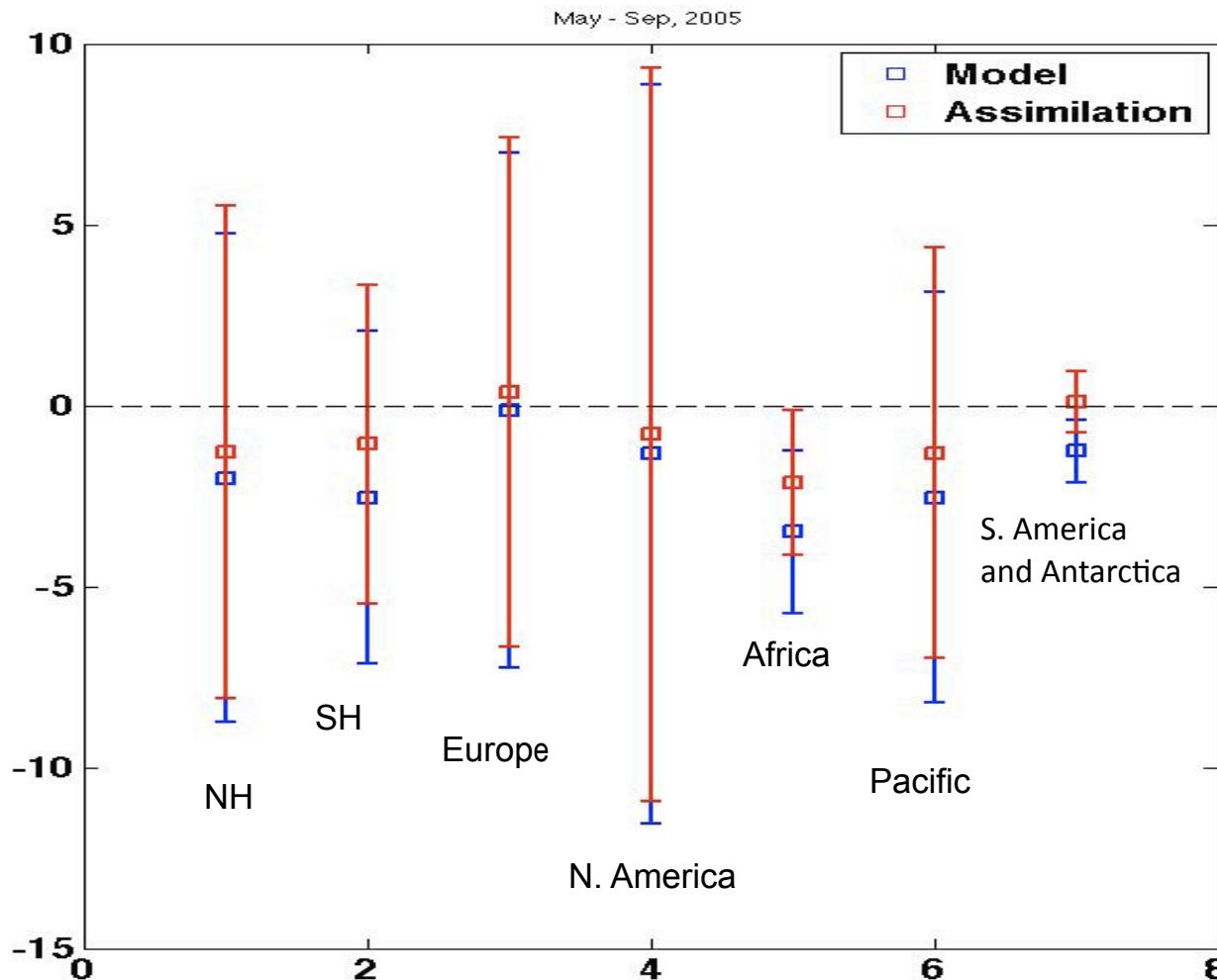
Red = mean assimilation error is higher



# Regional Comparison with CMDL surface observations

March – November 2005

Error Bars  
Blue – model; Red - Assimilation



# Summary of In-Situ O-Fs

- Model values are consistently larger than CMDL observations.
- Consistent improvement in mean differences.
- Regional comparison shows improvement everywhere except Europe.
- Error bars show that model is most accurate in Europe (hence the difficulty to show improvements).

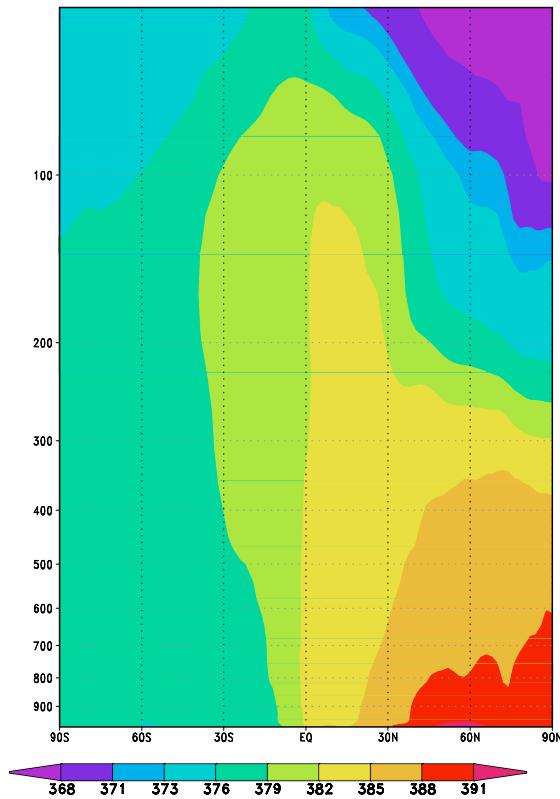
# Impact on CO<sub>2</sub> fields

- Zonal mean fields on April 15, Aug 15 and Nov 1, 2005.
- Monthly average surface CO<sub>2</sub> for April and August, 2005.
- Monthly average CO<sub>2</sub> at 500 hPa, for April and August, 2005.

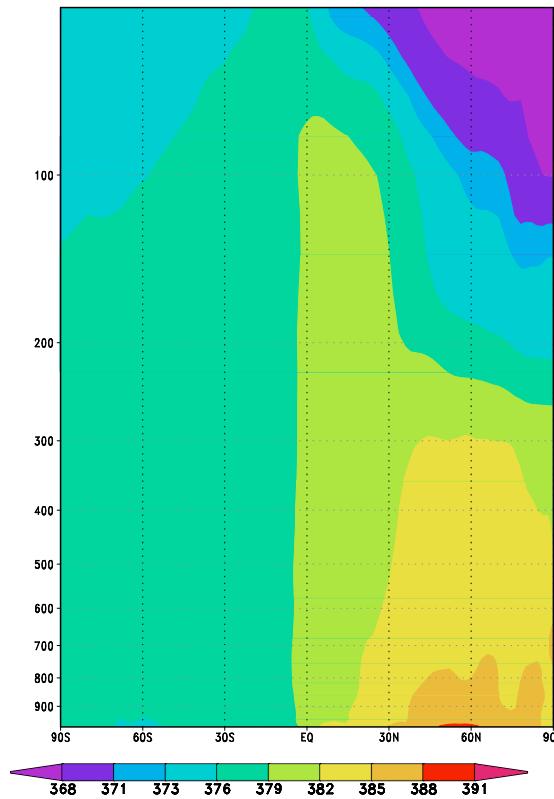
# Zonal Mean CO<sub>2</sub>

## April 15, 2005

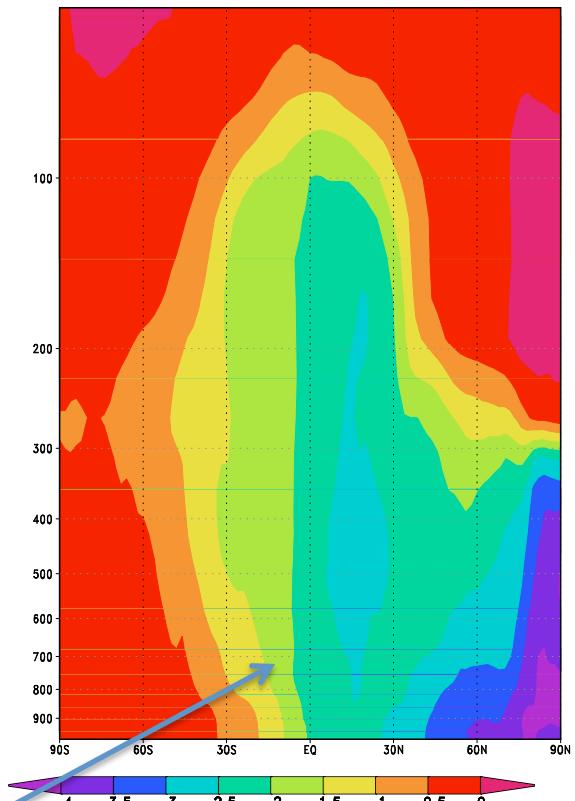
Model Run



Assimilation



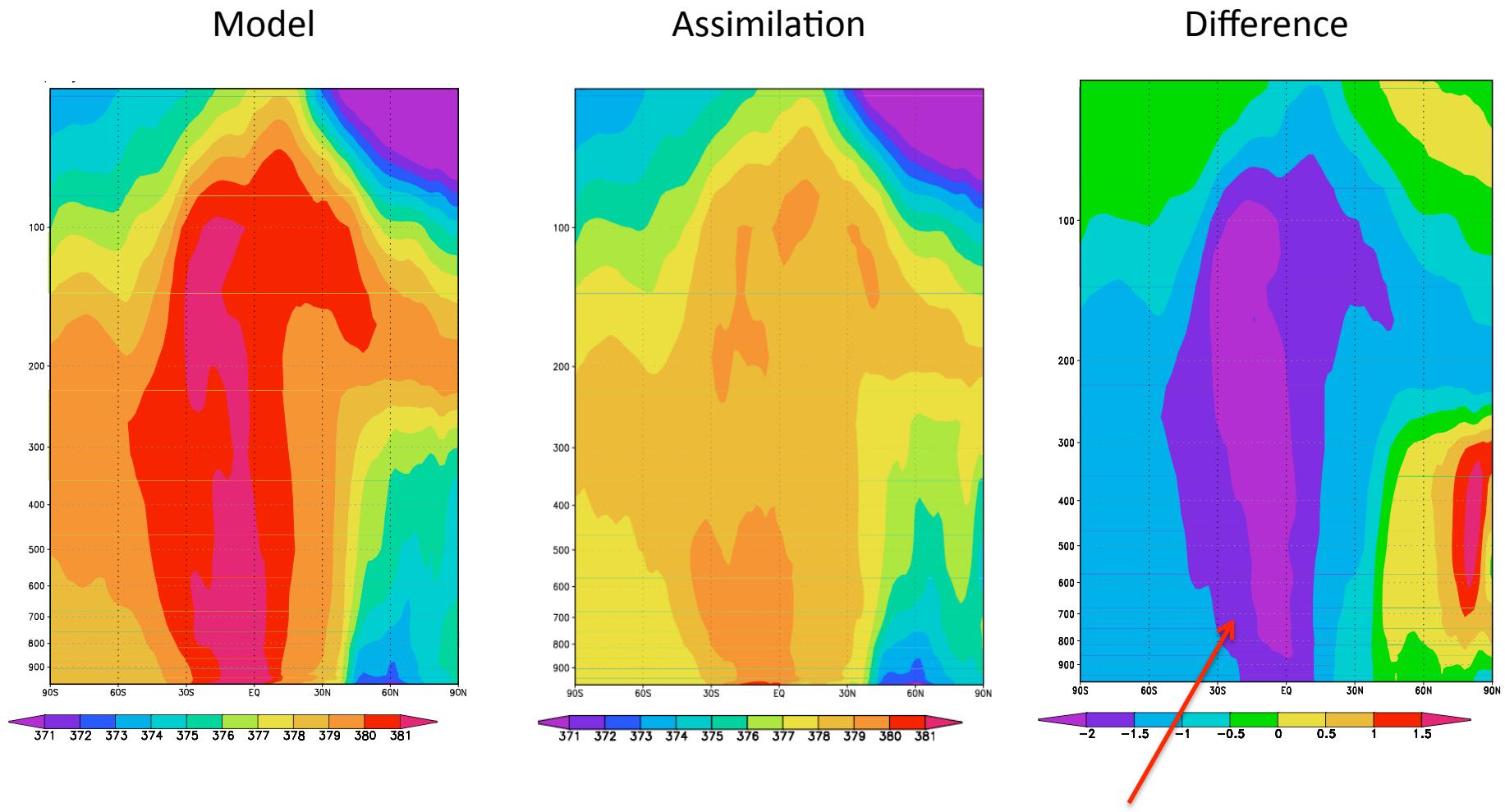
Difference



CO<sub>2</sub> reduced globally

# Zonal Mean

## August 15, 2005

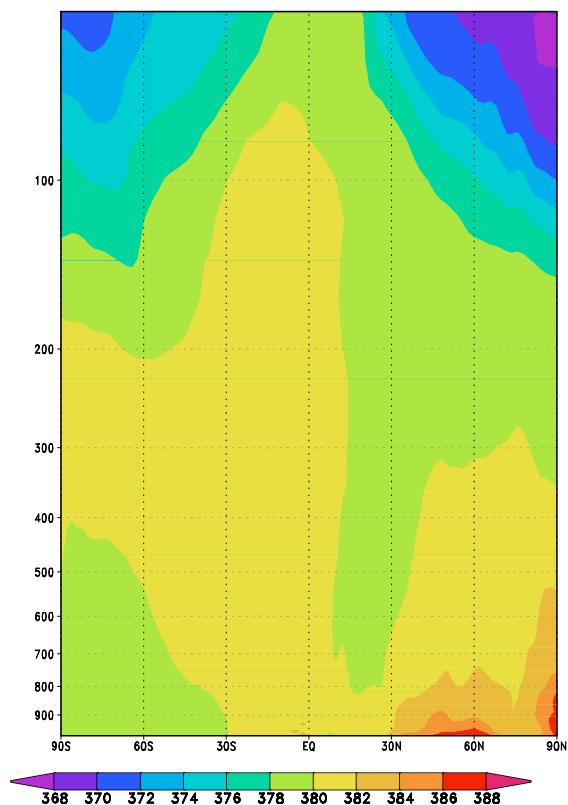


Reduction in CO<sub>2</sub> over entire column

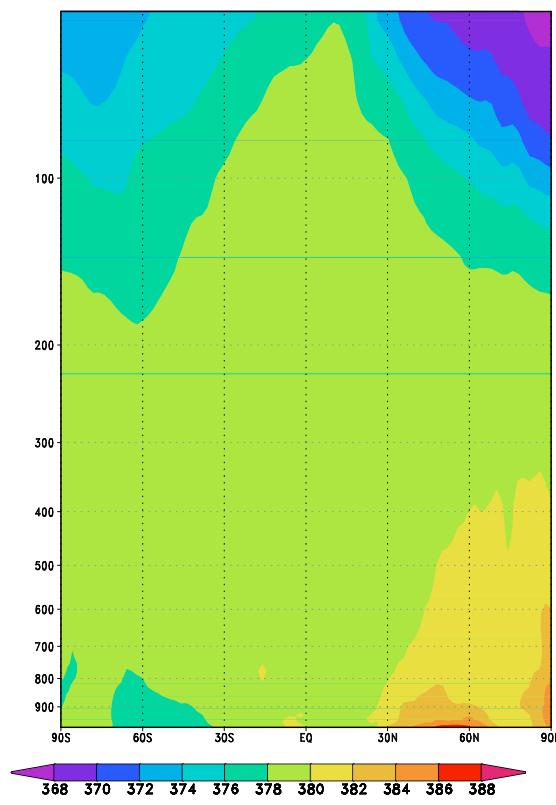
# Zonal Mean

## Nov 1, 2005

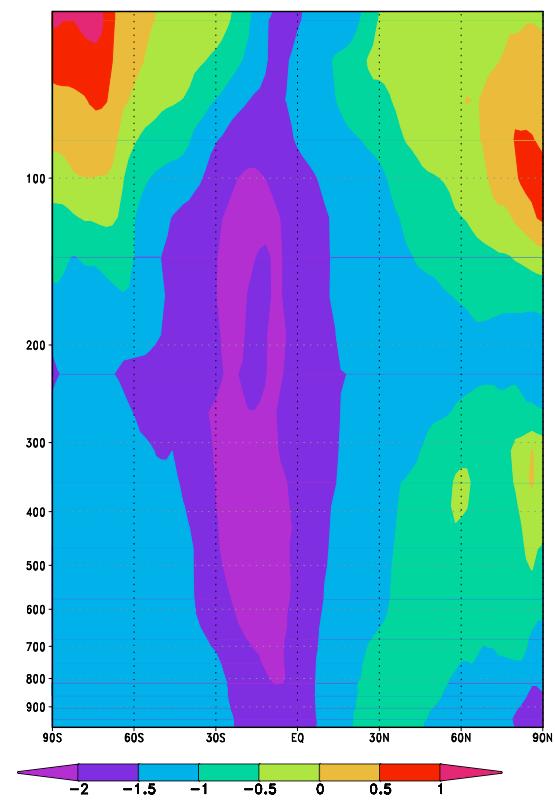
Model



Assimilation

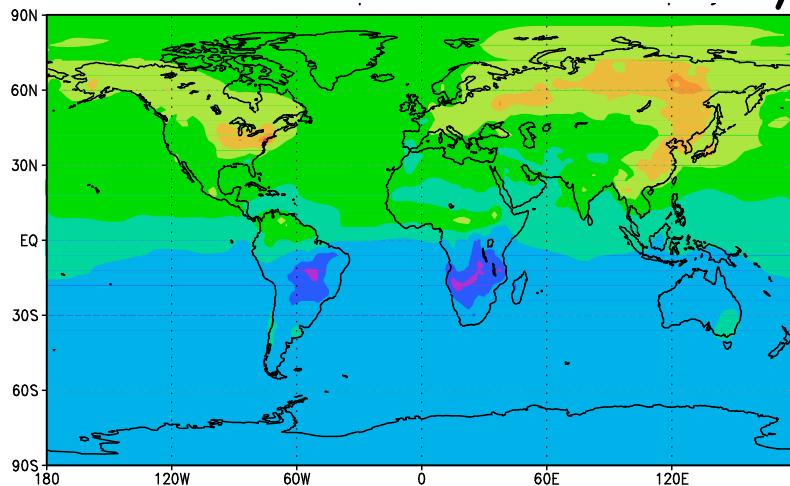


Difference

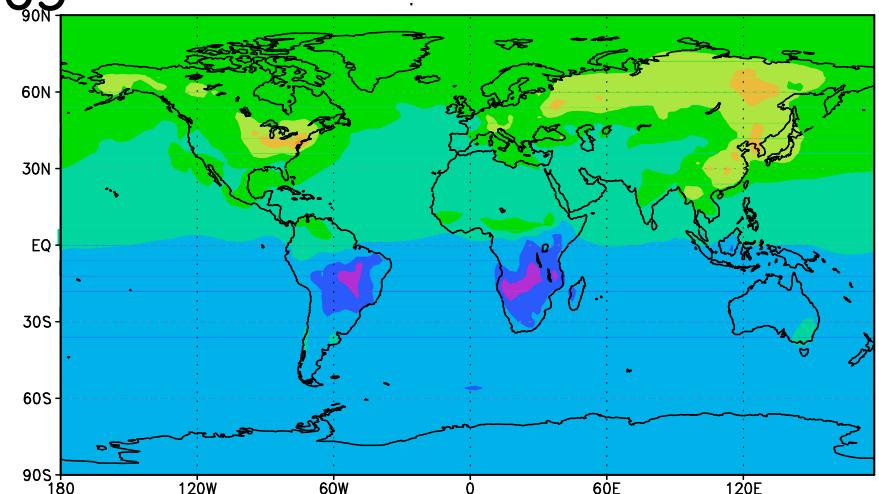


Model

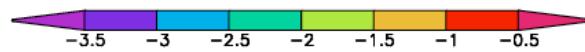
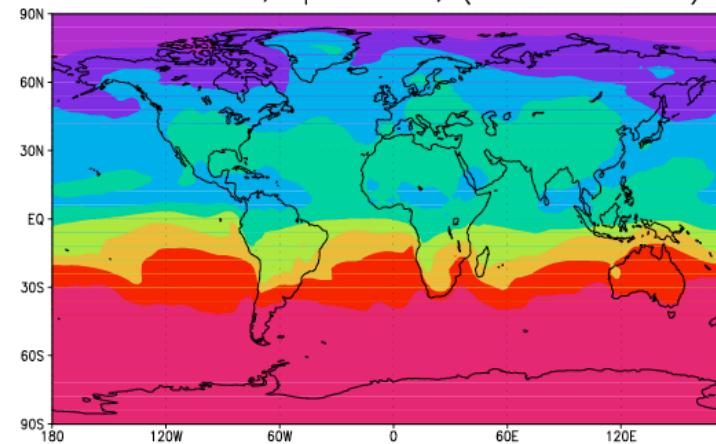
# Mean Surface Layer April 2005



Assimilation

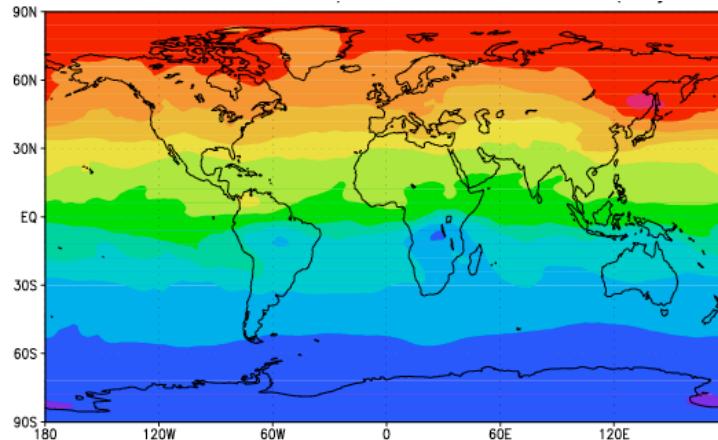


Difference



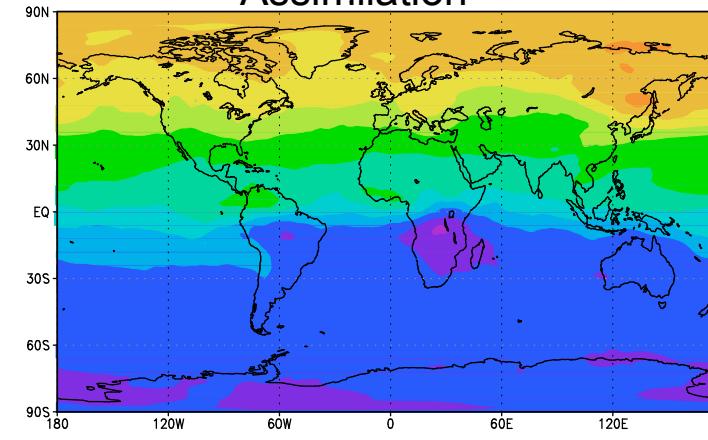
# Mean CO<sub>2</sub> at 500 hPa

Model

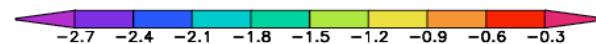
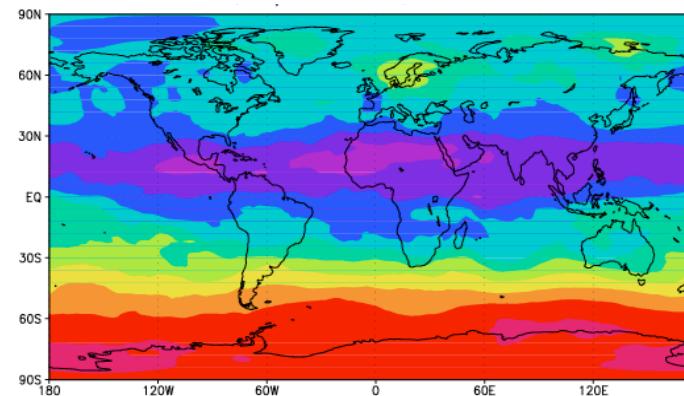


April 2005

Assimilation

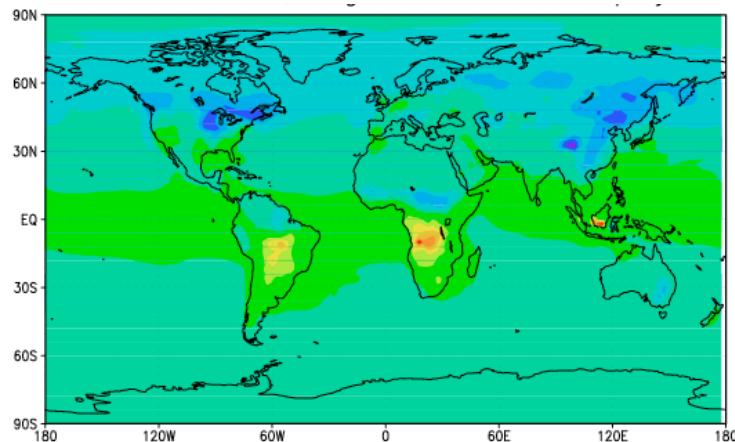


Difference



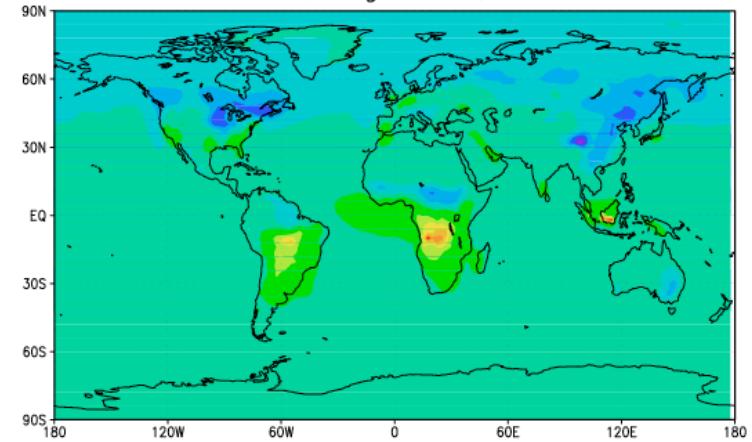
## Mean Surface layer

Model

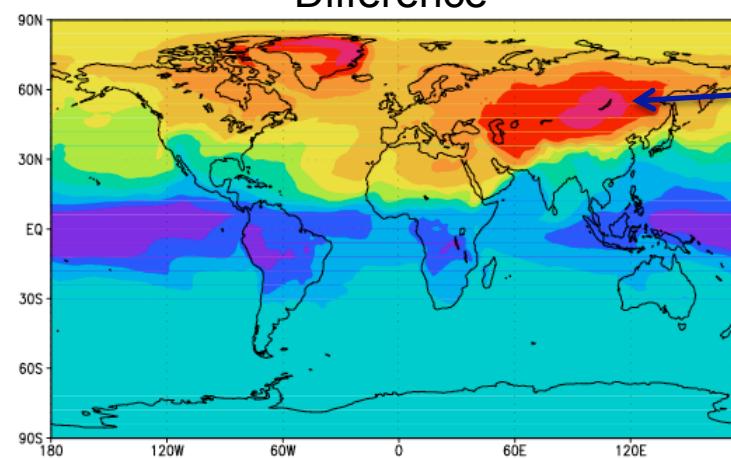
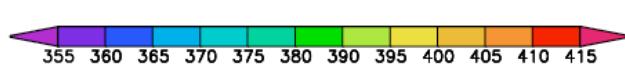


August 2005

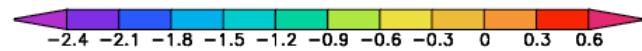
Assimilation



Difference



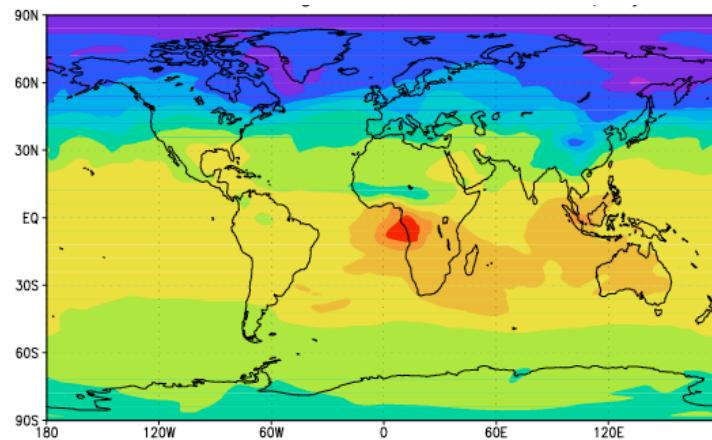
Increased CO<sub>2</sub> in Siberia



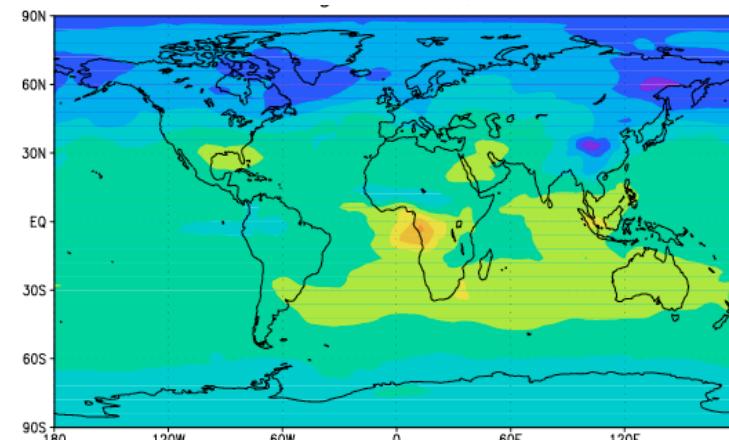
# Mean CO<sub>2</sub> at 500 hPa

August 15, 2005

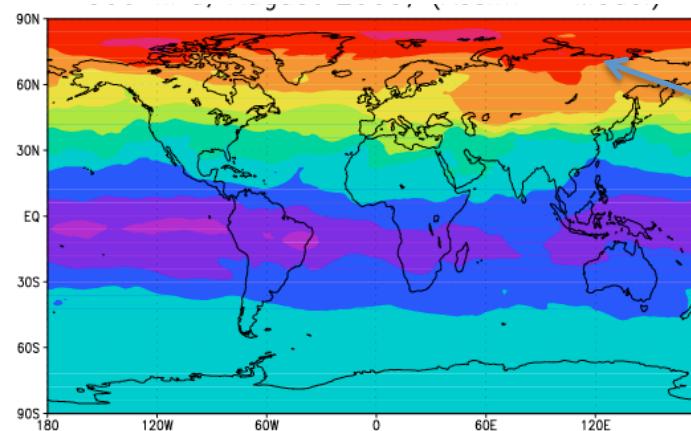
Model



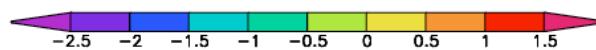
Assimilation



Difference



General increase at high latitudes  
and decrease in tropics



# Conclusions

- Tuning of background errors indicates an appropriate error standard deviation of about 0.1 % of CO<sub>2</sub> mixing ratio.
- Comparisons with CMDL surface data indicate that AIRS assimilation is improving the accuracy of surface values of CO<sub>2</sub> in GEOS5.
- Differences between GEOS5 and AIRS CO<sub>2</sub> can parameterized by hemisphere, with a systematic negative bias in the model during winter.

# Near term plans

- Comparison with JAL and other aircraft data.
- Further assimilation experiments with altered emissions, convection parameters .
- Assimilate a subset of observations.